A detailed 3D cutaway diagram of the sPHENIX detector at the Relativistic Heavy Ion Collider (RHIC). The diagram shows the complex internal structure, including the central barrel, endcap calorimeters, and various subdetectors. The components are color-coded to distinguish different parts of the detector. The background is a light blue gradient.

SPACAL Test beam comparison in sPHENIX simulation

Jin Huang (BNL)

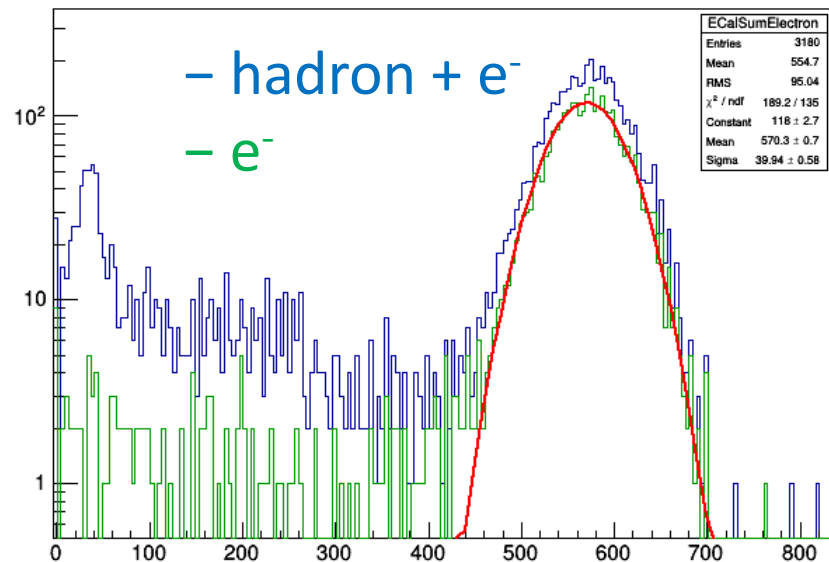
many thanks to

- Oleg Tsai
- Alex Kiselev
- Craig Woody
- John Haggerty

Overview

- ▶ One of the long last concern is lack of beam test calibration for our simulation
- ▶ Obtained eRD1 2014 beam test geometry and data with many help from Oleg Tsai, Alex Kiselev and Craig Woody
- ▶ Implemented in Geant4 -> SPACAL towering -> digitization

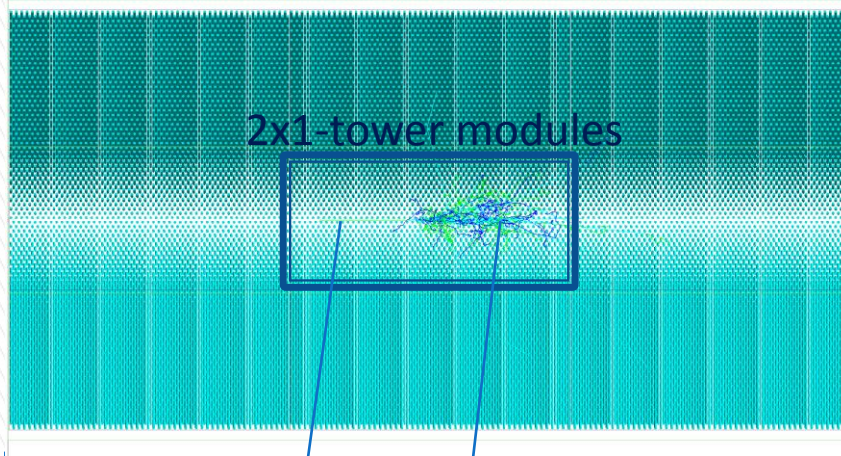
SPACAL prototypes in 2014 Fermilab beam test



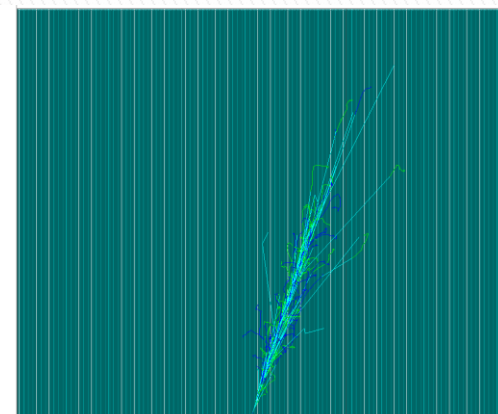
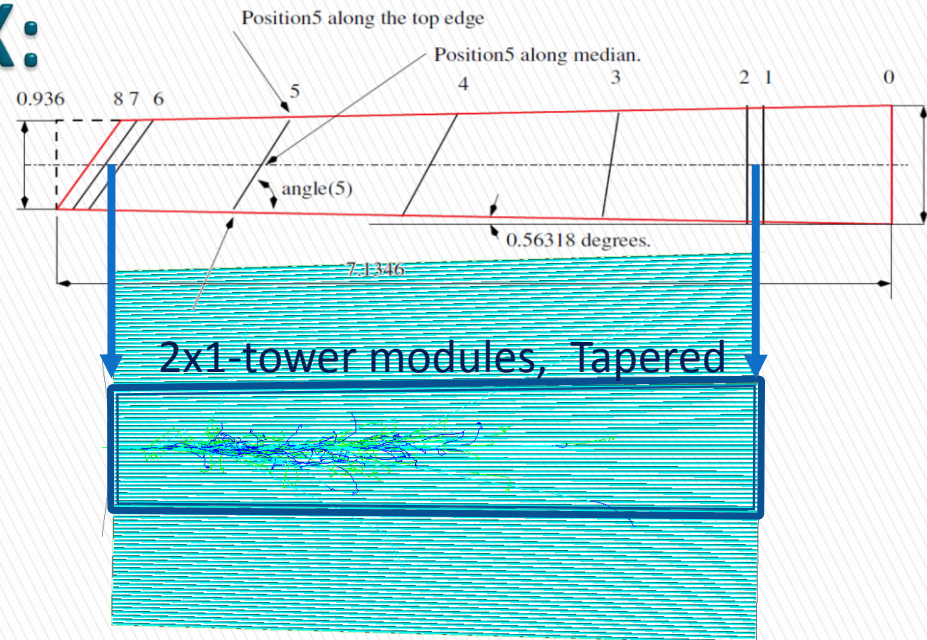
Courtesy : O. Tsai (UCLA)

Test beam in sPHENIX:

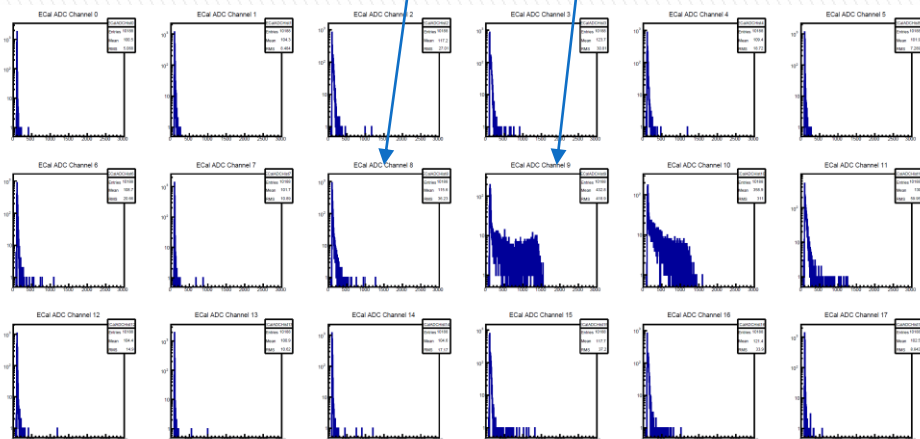
More detailed views of fibers
($\phi 500\mu\text{m}$ double cladding)



Particle view
(half cm front Al cover not shown)



Side views
(17 degree indenting as in test beam, 2.4-2.7% energy spread and half-cm front Al cover not shown)



Beam test data, eRD1 2014

Further refine the simulation VS reality

New from last week

- ▶ Implemented the beam momentum spread
 - 2.4% for 8 GeV/c beam, 2.7% for 4 GeV/c beam
- ▶ Baseline simulation configuration (same as 3rd iteration of production):
 - **Hadronic model:** QGSP_BERT_HP
 - **Light production:** Geant4 default Birk model (G4EmSaturation::VisibleEnergyDeposition)
 - **Group Geant4 hits** into fibers then into towers
 - **Digitalization** with test beam performance:
 - photon fluctuation (500p.e./GeV, Poisson model)
 - Pedestal noise (2ADC)
 - Zero suppression of (4ADC)
- ▶ Comparison to three tunes of the hadronic model
 - Our baseline
 - Tuning of the production threshold
 - Alex K.'s study used a 1um production threshold cut in EICROOT simulation.
 - Tested in our software
 - Use of the CALICE Birk constant
- ▶ Estimation for the beam composition: ~10% muon in anti-electron cut sample:

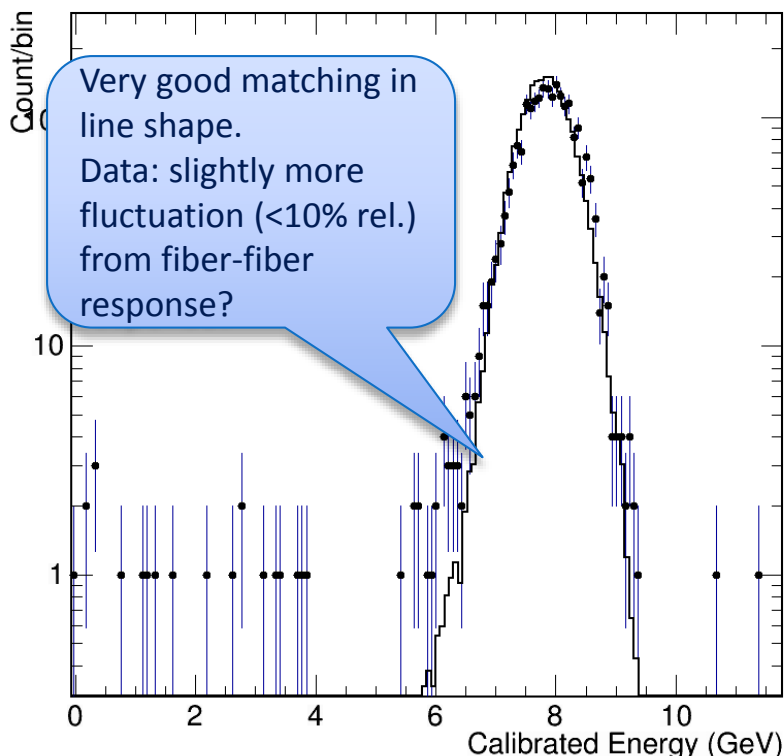
sPHENIX beam test, Liang, Xiaochun and John H.

	4 GeV	8 GeV	16 GeV	25 GeV	32 GeV	40 GeV	50 GeV	60 GeV
pion	32.1%	39.8%	67.2%	85.7%	91.9%	94.6%	96.5%	97.2%
electron	63.7%	56.4%	26.1%	8.9%	3.7%	1.6%	0.6%	0.3%
muon	4.2%	3.8%	6.7%	5.4%	4.4%	3.8%	2.9%	2.5%

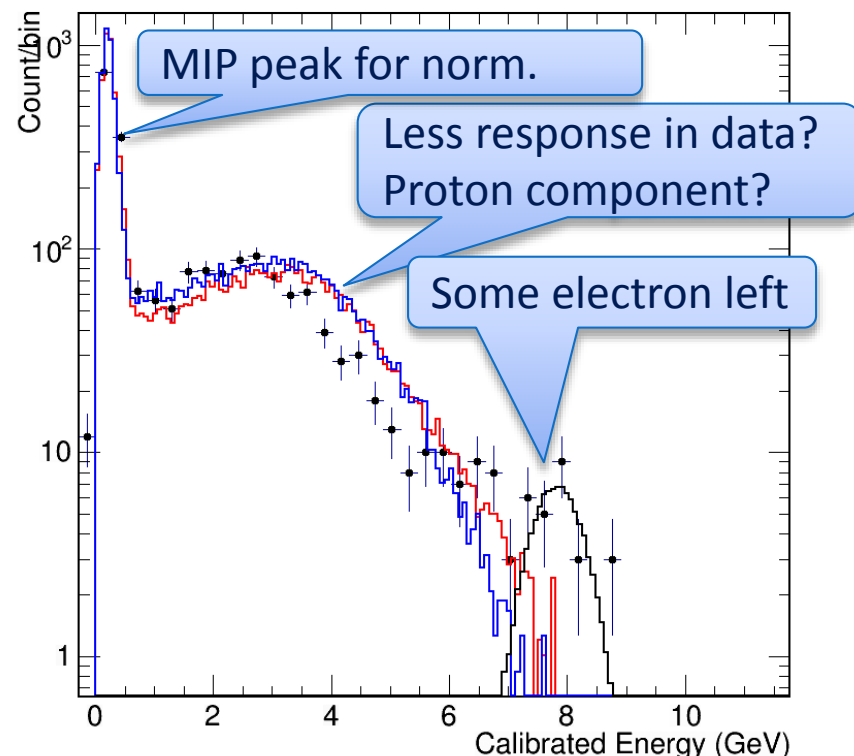
**Test Beam
Composition:**

Test beam comparison: 8 GeV beams shower in Geant4 VS data

Electron Sim (line) VS data (point)



Pion- (red) K- (blue) e contain. (black) Sim VS data

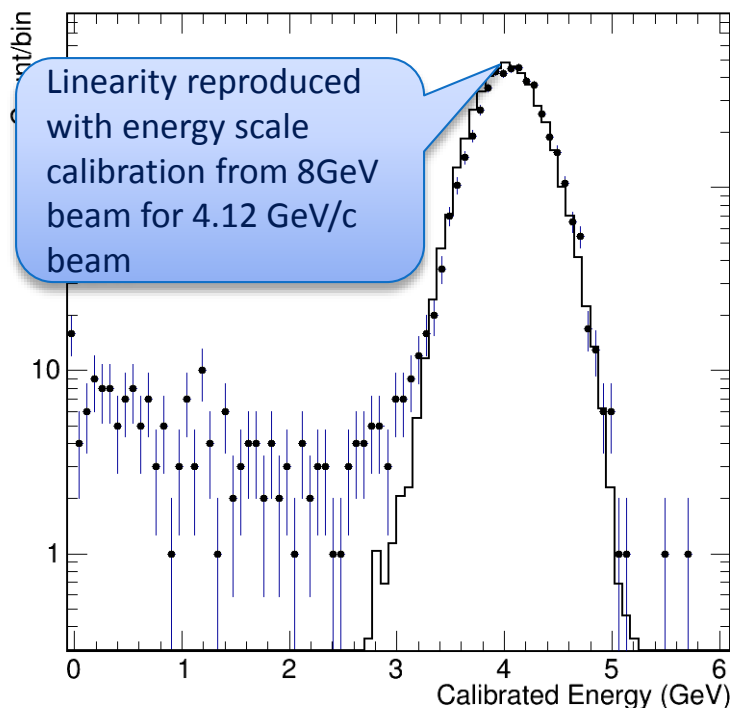


Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

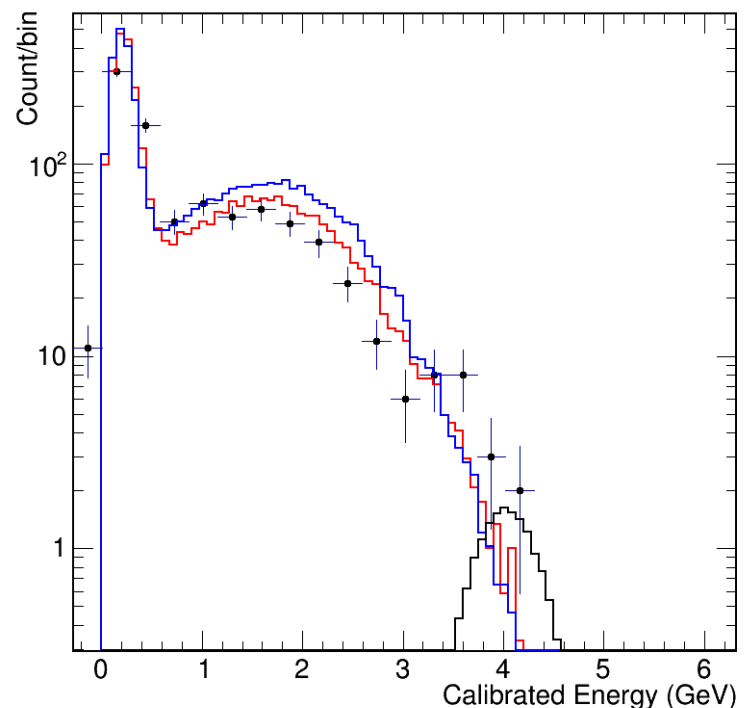
Test beam comparison:

4.12 GeV/c beams shower in Geant4 VS data

Electron Sim (line) VS data (point)



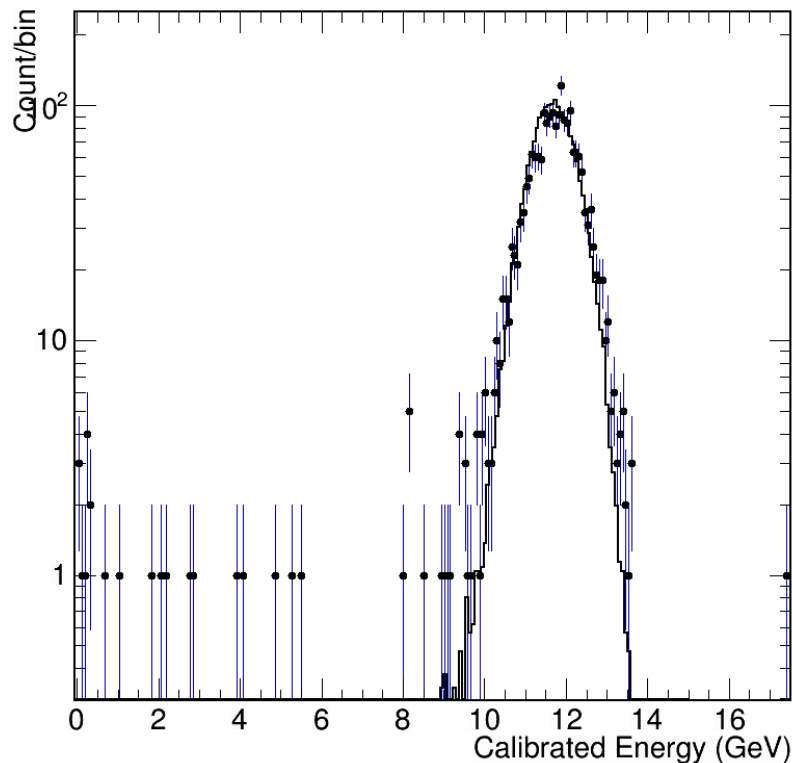
Pion- (red) K- (blue) e contain. (black) Sim VS data



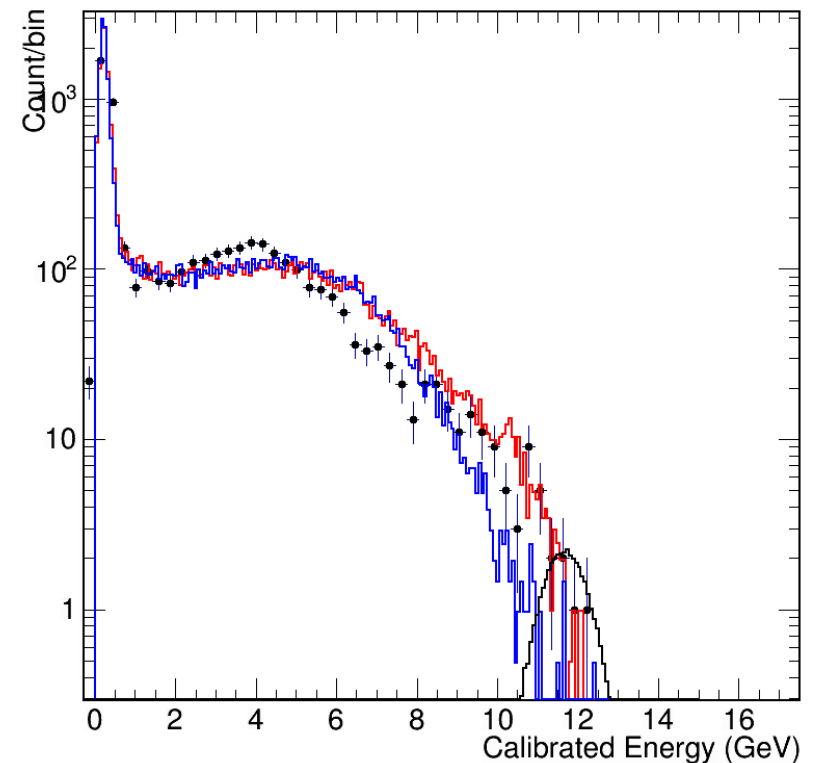
Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

Test beam comparison: 12 GeV/c beams shower in Geant4 VS data

Electron Sim (line) VS data (point)



Pion- (red) K- (blue) e contain. (black) Sim VS data

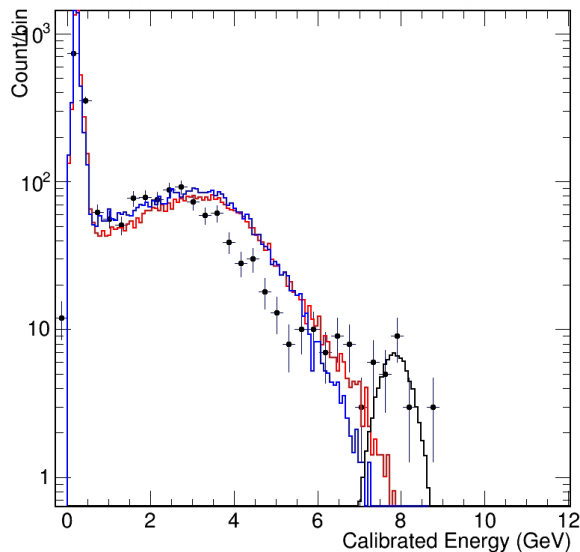


Hadronic model tuning comparison

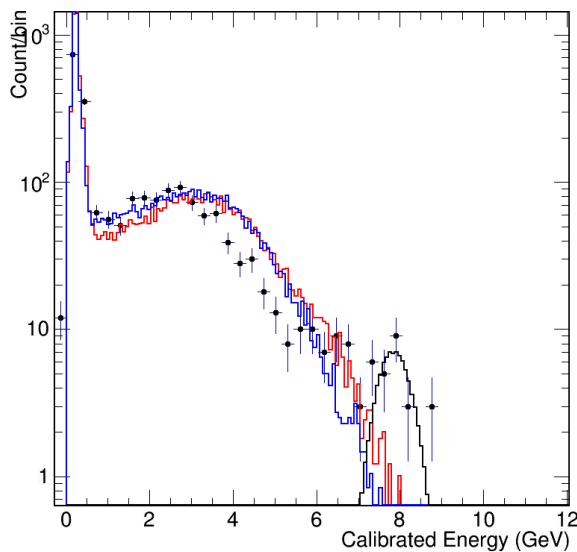
8 GeV hadron data VS sim

More plots in backup. Example checks in hadron response for different tunings:

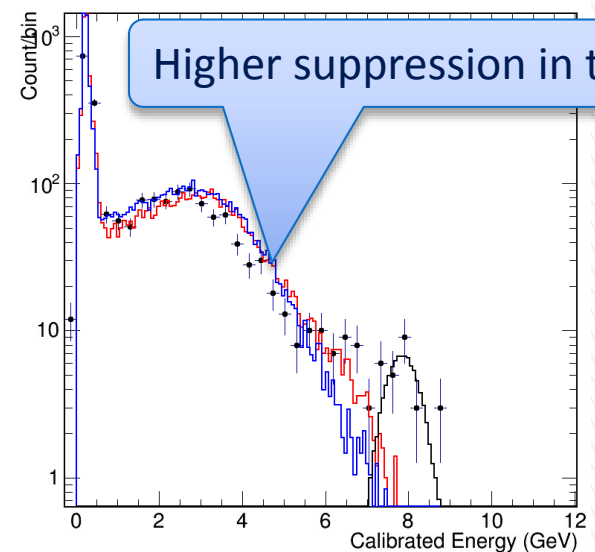
Pion- (red) K- (blue) e contain. (black) Sim VS data



Pion- (red) K- (blue) e contain. (black) Sim VS data



Pion- (red) K- (blue) e contain. (black) Sim VS data



Default configuration
production threshold of 1mm,
Birk constant = 0.00794 cm/MeV

Baseline configuration
+ production threshold of 1 μm

Baseline configuration
+ CALICE Birk constant
0.0151 cm/MeV

Next step

- ▶ Use the test beam data comparison in pre-CDR line-shape plot as simulation justification.
- ▶ Use the same towering -> digitalization strategy in pre-CDR analysis
- ▶ Discussion: strategy to save/pass down tower information:
Geant4 RawTower -> Digitalized Tower -> Calibrated Tower -> Clustering/Jet Finding

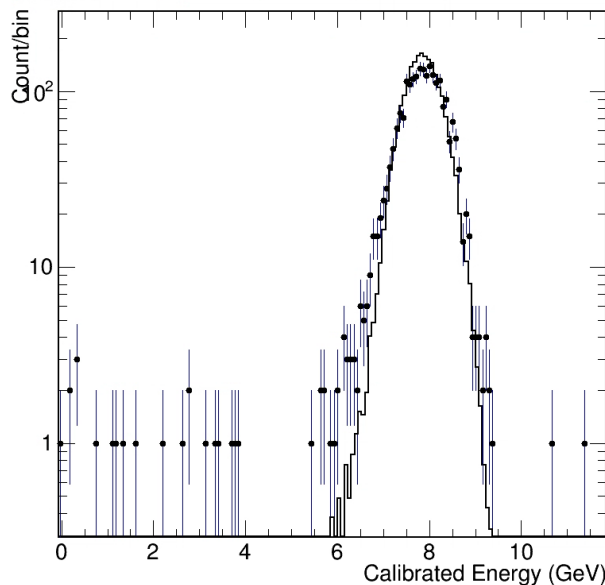
Extra information



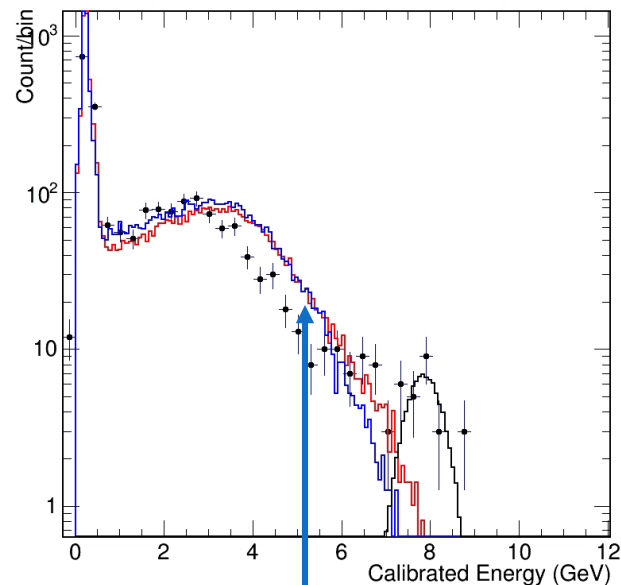
8 GeV beams
VS Production threshold

Geant4 Default
production
threshold (1mm)

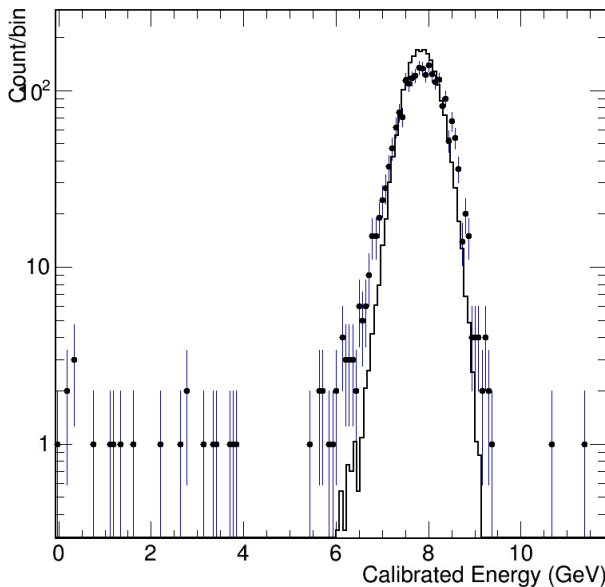
Electron Sim (line) VS data (point)



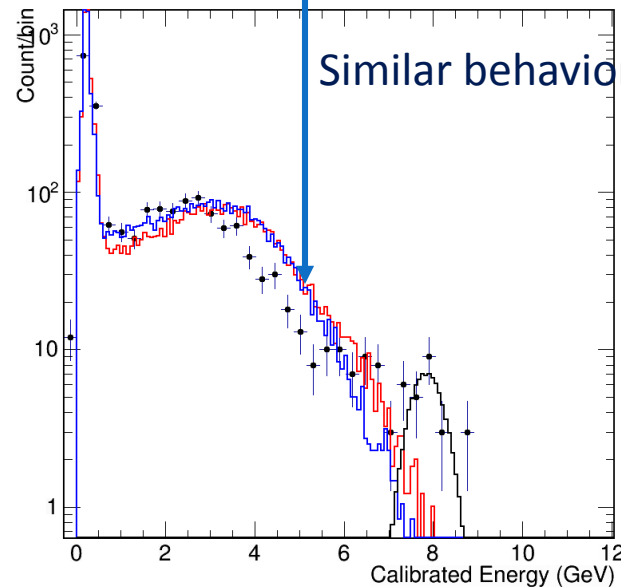
Pion- (red) K- (blue) e contain. (black) Sim VS data



Electron Sim (line) VS data (point)



Pion- (red) K- (blue) e contain. (black) Sim VS data



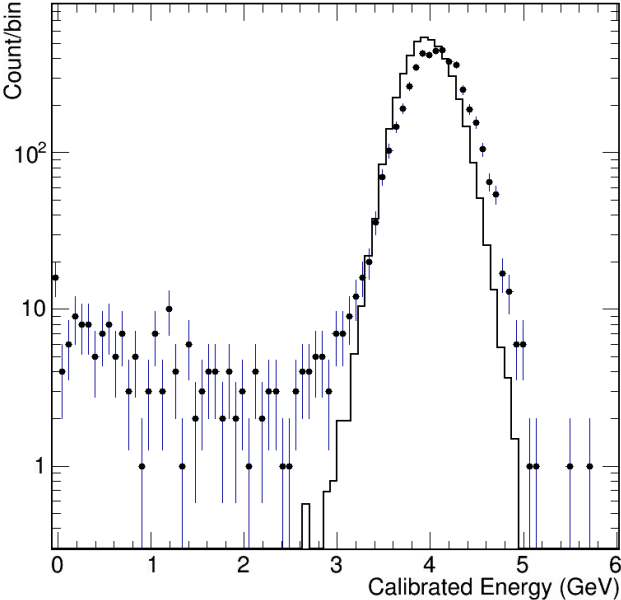
Similar behavior

Production
threshold cut
(1um)

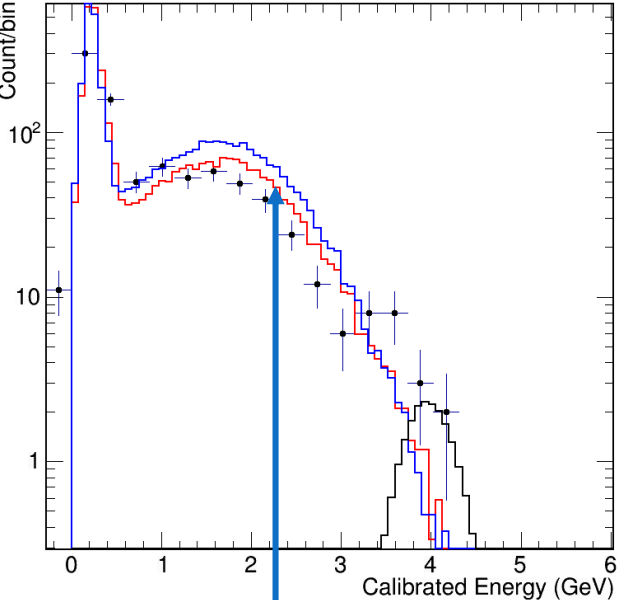
4 GeV beams
VS Production threshold

Geant4 Default
production
threshold (1mm)

Electron Sim (line) VS data (point)

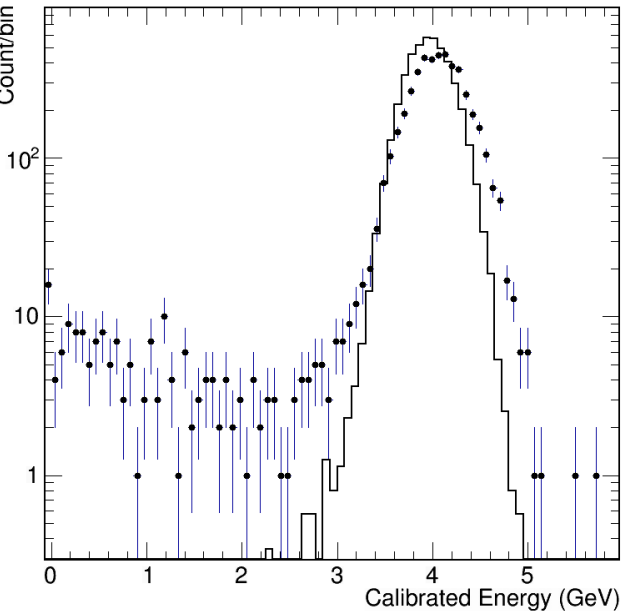


Pion- (red) K- (blue) e contain. (black) Sim VS data

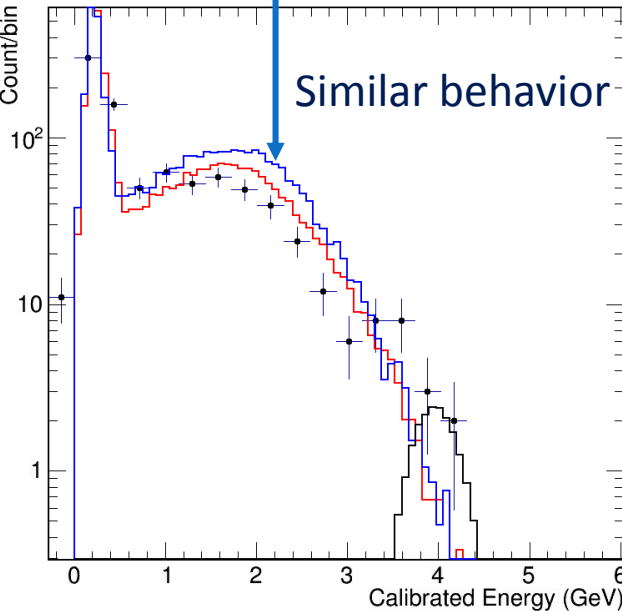


Production
threshold cut
(1um)

Electron Sim (line) VS data (point)

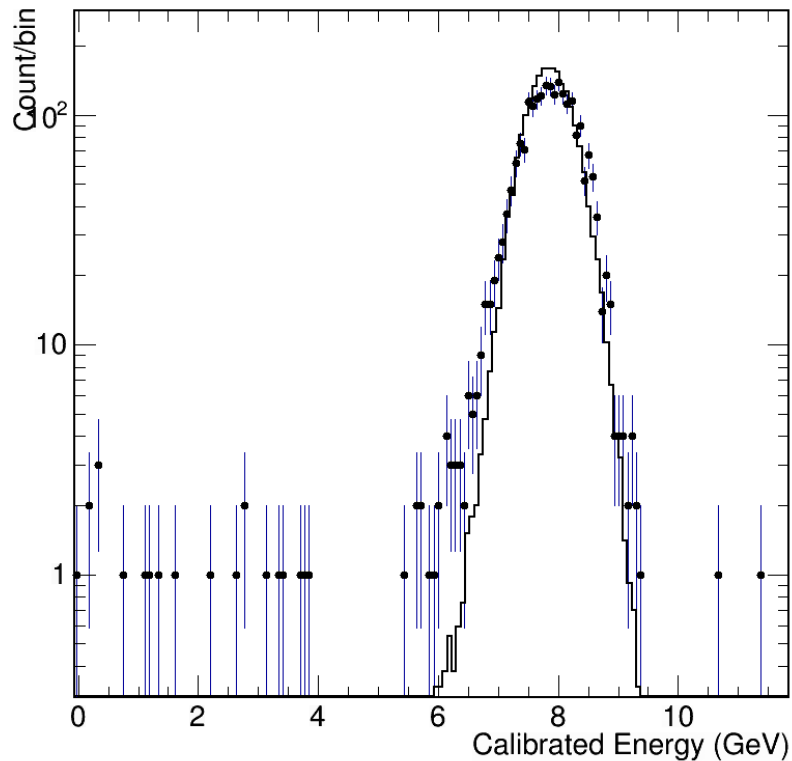


Pion- (red) K- (blue) e contain. (black) Sim VS data

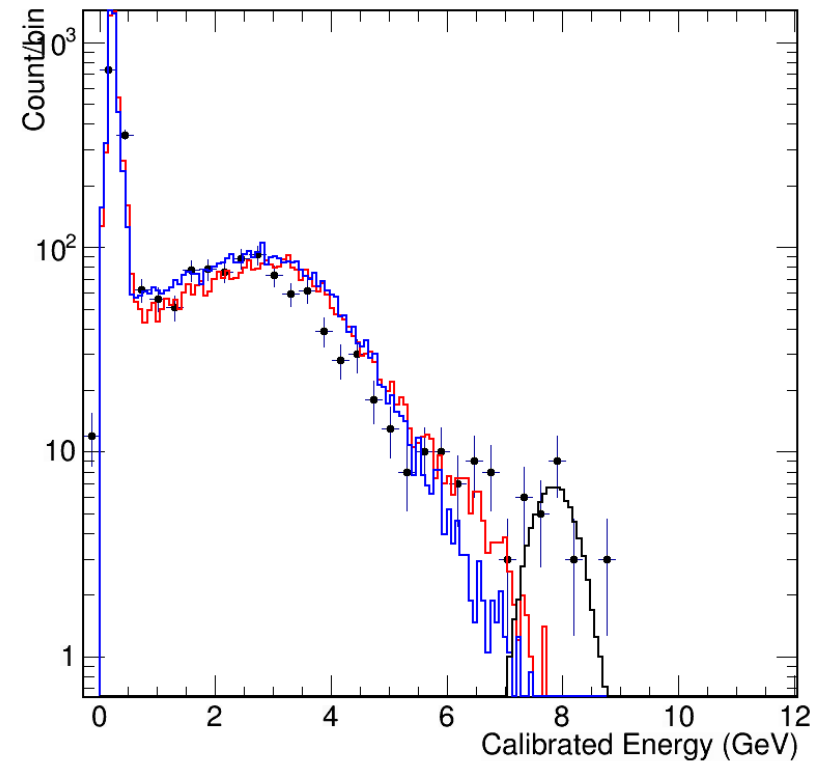


CALICE Birk Constant

Electron Sim (line) VS data (point)

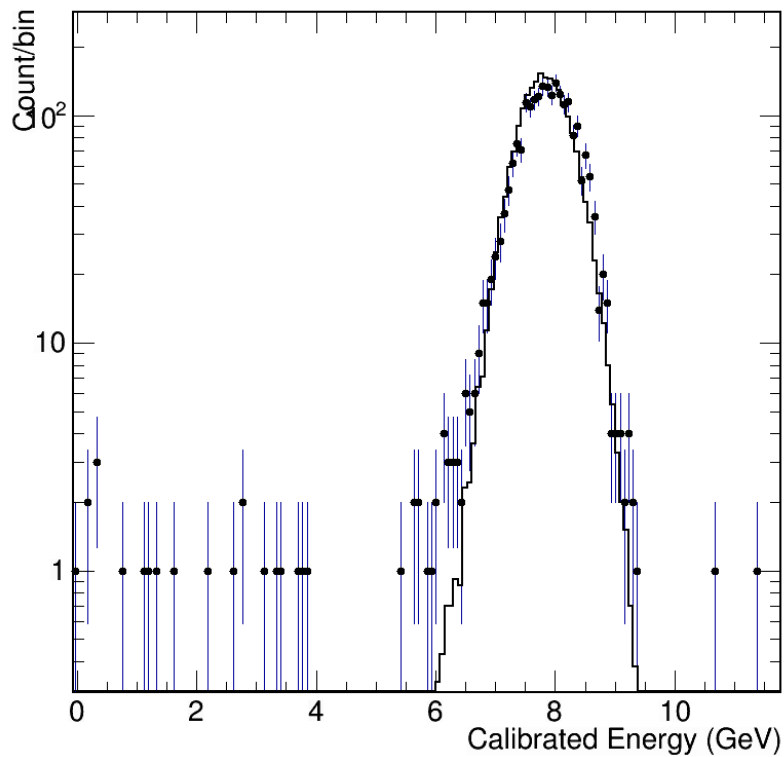


Pion- (red) K- (blue) e contain. (black) Sim VS data



CALIC + Towering

Electron Sim (line) VS data (point)



Pion- (red) K- (blue) e contain. (black) Sim VS data

